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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 270

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ July 29, 1915.

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CEREAL EXPERIMENTS AT THE WILLISTON STATION

By

F. RAY BABCOCK, Scientific Assistant, Office of Cereal Investigations

(In cooperation with the North Dakota Agricultural Experiment Station)

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WASHINGTON
GOVERNMENT PRINTING OFFICE
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INTRODUCTION.

The experiments with cereals at the Williston substation in North Dakota have been conducted cooperatively since 1908 by the Office of Cereal Investigations of the Bureau of Plant Industry and the North Dakota Agricultural Experiment Station. The memorandum of understanding between the two parties specifies that—

The objects of these cooperative investigations shall be (1) to improve the wheat industry of the northern Plains region by discovering or producing varieties better than those now grown, especially with regard to nitrogen content, yield, earliness, drought resistance, etc.; (2) to conduct similar experiments with oats, barley, and other cereals when it may be desirable; and (3) to determine the effect of changes of environment upon the growth of cereals, particularly the composition of the wheat kernel.

[1] The Williston substation was established in 1908 by the North Dakota Agricultural Experiment Station and has since been operated as one of the several "subexperiment stations" located at various points in the State. President J. H. Worst, of the North Dakota Agricultural College, was director of the State station from the time the Williston substation was established until January 1, 1914, when Mr. Thomas P. Cooper was appointed director. Prof. J. H. Shepperd has been vice director of the station during the entire period. Mr. E. G. Schollander was superintendent of the Williston substation from the first year of its operation, 1908, until April 1, 1914. Upon his resignation, Mr. Charles H. Ruzicka took charge. In 1908 the writer was appointed special agent in the Office of Cereal Investigations to take charge of the cooperative cereal work and in 1914 was appointed scientific assistant.

Note.—This bulletin presents the results of varietal tests with cereals which have been conducted at Williston, N. Dak., from 1908 to 1914, in cooperation with the North Dakota Agricultural Experiment Station. The subject is of interest to experimenters throughout the Great Plains area, and especially in western North Dakota and eastern Montana.

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Data on the cooperative cereal work are included in each of the several annual reports published by the Williston substation.[1] This bulletin summarizes the cooperative cereal experiments for a period covering seven years, and such conclusions as are warranted are presented.

DESCRIPTION OF THE SUBSTATION.

The results obtained at the Williston substation are applicable only to portions of North Dakota and eastern Montana. Conditions very similar to those at Williston occur in all of North Dakota lying west of the one hundred and first meridian and the Missouri River, and in the eastern portion of Valley, Custer, and Dawson Counties, Montana. The one hundred and first meridian runs through Bottineau, McHenry, and McLean Counties in North Dakota.

To determine just how far the results obtained at Williston are applicable to other parts of the district, it is necessary to consider the variability of the climate and other conditions. In order that such comparisons may be made, a detailed description of the Williston substation is here given.

LOCATION.

The Williston substation is located about one-half mile north of the city of Williston and 1½ miles north of the Missouri River, in the south-central part of Williams County. It comprises 160 acres, of which a part is creek-bottom flat and the remainder level or rolling bench land above the creek bottom. The elevation is approximately 1,900 feet above sea level.

The Little Muddy Creek drains the locality to the north for several miles, borders the substation on the east, and empties into the Missouri River. On both sides of this creek is an alluvial valley, varying in width from less than a mile to more than 5 miles.

Outside of this valley there are two extensive types of topography, as well as two soil types: (1) The gently rolling or nearly level areas of good agricultural land of the soil type known as Williams loam and (2) the sharply rolling hills along the streams, composed of a stony, rock-strewn soil known as Williams stony loam.

Until within the last few years all of western North Dakota and eastern Montana was a range country. Now, however, there are no large ranches except in rough areas where the raising of crops is difficult. The new settlers raise wheat almost exclusively during the first few years. After that they gradually adopt a system of more diversified farming, including the growing of other small grains, corn, and legumes, and the keeping of live stock.

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[1] North Dakota Agricultural Experiment Station, Williston Subexperiment Station, Annual Reports, 1908 to 1913.

PHYSICAL FACTORS.

A summary of crop yields for a series of years should be accompanied by a statement of the physical factors that influence crop production. The most important physical factors are (1) the soil; (2) the seasonal and annual rainfall; (3) the seasonal evaporation; (4) the wind, with special reference to that which passes directly over the ground surface during the growth of the crop; and (5) the temperature, especially the killing frosts of spring and autumn that limit the growing season. The data on these factors, which follow, have been recorded at the Williston substation and at the station of the United States Weather Bureau in Williston.

SOIL.[1]

The soil of the Williston substation is of an alluvial character, but it is variable in type. It is not typical of most of the best farming land outside of the valley. The creek-bottom flat consists of a heavy clay of the type described by the Bureau of Soils as Laurel clay. The larger portion of the substation consists of level or rolling land somewhat higher than the creek bottom. The somewhat variable soil on this portion is of the type known as Williston sandy loam. Water for irrigation is available on this part of the station farm.

That portion of the substation where the cereal experiments are conducted consists of a fairly level upland area, on which irrigation water is not available. The soil, which is fairly uniform in type, is classed as Laurel fine sandy loam.

NATIVE VEGETATION.

A biological survey was made of the Williston area in 1906.[2] The most important native vegetation found prevailing on the prairie included grama grass (*Bouteloua oligostachya*), buffalo grass (*Bulbulis dactyloides*), western wheat-grass (*Agropyron occidentale*), slender wheat-grass (*Agropyron tenerum*), and needle grass (*Stipa comata* and *Stipa viridula*). The grama grass grows abundantly over the prairie and makes a very nutritious pasture and excellent hay. The buffalo grass is just as nutritious, but is found more in spots and is never tall enough for hay. The western and slender wheat-grasses are found in the wild state and will replace the other native grasses when the sod is broken. They are grown extensively for the production of hay.

RAINFALL.

Table I shows the precipitation record for the Williston locality for a period of 36 years, from 1879 to 1914, inclusive. Previous to 1893 the weather records were kept at Fort Buford, N. Dak., 20

[1] For a full report on the soils of the Williston locality, see Rice, T. D., Willard, R. E., and Weaver, J. T., Soil survey of the Williston area, North Dakota. In U. S. Dept. Agr. Bur. Soils Field Oper. 1906, 8th Rpt., p. 999–1022, fig. 34, 1908.

[2] Bell, W. B. Report of the biological survey of North Dakota. In 4th Bien. Rpt. Agr. Col. Survey N. Dak., p. 28–51, 1910.

miles west of Williston. In December of that year the station of the Weather Bureau was moved to Williston. The Biophysical Laboratory of the Bureau of Plant Industry installed weather instruments at the Williston substation in 1909, and since that year the rainfall recorded there for the months during the growing season (April to July, inclusive) is used in the rainfall table. The growing season for the small grains extends from April to about August 1 to 10. The crops are so nearly mature on August 1, however, that precipitation after that date has little effect on yields. The table shows the rainfall, by months for the growing season and for the year, with monthly averages, maxima, and minima.

TABLE I.—*Monthly, annual, and seasonal precipitation, with the average, maximum, and minimum for each month, at Williston, N. Dak., 1879 to 1914, inclusive.*

[Data (in inches) from the records of the U. S. Weather Bureau and the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.	April to July, seasonal.
1879	0.58	0.59	0.03	2.75	5.56	3.35	3.63	0.18	Trace.	1.55	0.37	1.68	20.27	15.29
1880	.10	.51	.21	.74	4.02	5.46	4.17	2.36	1.04	.90	.66	3.08	23.25	14.39
1881	1.98	1.10	1.17	1.34	1.00	3.45	1.22	1.10	.58	.39	.39	.09	13.81	7.01
1882	.26	.29	.69	.94	1.61	1.87	2.25	.16	2.86	1.00	.29	.51	12.73	6.67
1883	1.98	.36	.91	.48	.59	.97	1.69	1.96	.22	1.41	.14	.11	10.82	3.73
1884	.11	.12	.10	1.30	.14	.99	1.87	1.06	.53	.44	.31	.40	7.37	4.30
1885	.64	.44	.03	1.71	1.02	6.05	3.02	1.50	.26	.19	.56	.14	15.56	11.80
1886	.41	.71	.31	2.25	1.14	.93	.56	.87	.05	1.57	.59	.55	10.24	4.88
1887	.51	.18	.12	1.09	1.59	3.25	2.00	3.91	1.07	1.43	.10	.18	15.43	7.93
1888	.47	.33	.44	.61	.96	6.75	2.12	1.61	.62	.62	.10	.07	14.70	10.44
1889	.13	.30	.20	.60	2.69	1.03	.63	.95	1.13	.01	.37	.42	8.46	4.95
1890	.22	.18	.58	.60	1.58	5.23	1.06	.22	2.05	2.45	.03	.04	14.24	8.47
1891	.19	.14	.27	1.84	1.49	7.08	2.99	.78	.66	1.96	1.44	.14	18.98	13.40
1892	.14	.38	.38	2.65	.48	2.41	4.49	.62	.11	.15	1.12	1.33	14.26	10.03
1893	2.04	.31	.12	.38	4.79	1.84	1.85	.31	.64	1.14	.56	1.92	15.90	8.86
1894	.88	.20	2.23	2.07	3.15	4.68	.02	.73	1.50	1.05	.85	.40	17.76	9.92
1895	.53	.47	.07	2.52	3.02	3.67	2.55	1.03	.32	.35	1.91	.63	17.07	11.76
1896	2.02	.71	1.80	2.86	5.79	3.45	1.22	.72	.89	.34	2.10	.14	22.04	13.32
1897	.56	1.10	2.10	1.17	.72	2.71	1.36	.45	.58	.43	.85	.16	12.19	5.96
1898	.01	.74	1.25	1.08	1.21	4.56	1.93	.23	.99	2.08	.30	.06	14.44	8.78
1899	.58	.10	.79	.60	2.39	3.72	1.91	.56	.01	1.06	.13	.76	12.61	8.62
1900	.03	.85	1.25	.57	1.46	.65	2.34	4.47	2.24	1.03	.71	.21	15.81	5.02
1901	.54	.34	.26	.46	.71	8.84	2.71	.74	1.77	.14	1.02	.83	18.36	12.72
1902	.09	1.52	1.36	.53	2.69	3.92	3.43	1.26	.33	.32	.72	.68	16.85	10.57
1903	.40	.27	.09	.79	3.94	2.06	2.43	5.02	1.39	.05	.18	1.07	17.69	9.22
1904	.58	.59	1.57	.78	1.27	2.58	.56	.57	.12	.23	.01	.58	9.44	5.19
1905	.10	.14	.18	.04	1.74	3.44	1.94	.74	1.93	.06	.31	.04	10.66	7.16
1906	.82	.03	.16	1.59	4.55	8.80	.50	2.39	1.18	.26	1.00	.73	22.01	15.44
1907	1.03	.13	.66	.53	1.11	2.03	1.82	2.06	.45	.08	.02	.26	10.18	5.49
1908	.04	.39	.79	1.96	1.80	2.64	.60	1.11	2.18	1.18	.16	.01	13.49	7.00
1909	.31	.10	.12	.64	2.84	3.72	1.72	.38	1.27	.17	.20	.46	11.93	8.92
1910	.27	.34	1.23	1.40	1.30	1.65	1.27	1.69	.14	.05	.66	.28	10.28	5.62
1911	.56	.34	.42	.32	3.00	1.37	1.40	2.56	2.49	.53	1.25	.59	14.83	6.09
1912	.44	.17	.35	2.13	4.59	1.59	3.60	3.47	1.21	1.12	.14	.18	18.99	11.91
1913	.52	.14	.94	.15	1.05	2.15	2.60	5.50	1.13	.94	.15	Trace.	15.27	5.95
1914	.55	.28	.50	.49	1.31	7.98	2.32	3.55	.64	.38	.24	.33	18.47	12.00
Average	.57	.41	.66	1.17	2.17	3.52	1.99	1.58	.96	.75	.55	.53	14.90	8.86
Maximum	2.04	1.52	2.23	2.86	5.79	8.84	4.49	5.50	2.86	2.45	2.10	3.08	23.25	15.44
Minimum	.01	.03	.03	.04	.14	.65	.02	.16	Trace.	.01	.01	Trace.	7.37	3.73

The average annual precipitation for the period of 36 years, as shown by Table I, is 14.90 inches. The maximum for any one year was 23.25 inches (in 1880) and the minimum was 7.37 inches (in 1884). During the same period the average precipitation for the

growing season (April to July, inclusive) was 8.86 inches. The maximum for any one growing season was 15.44 inches (in 1906) and the minimum was 3.73 inches (in 1883).

The rainfall is presented in graphic form in figure 1. The entire height of the vertical columns represents the precipitation in inches for the different years and the black lower portion shows the rainfall for the growing season (April to July, inclusive) for the same years. The lower horizontal line represents the average seasonal

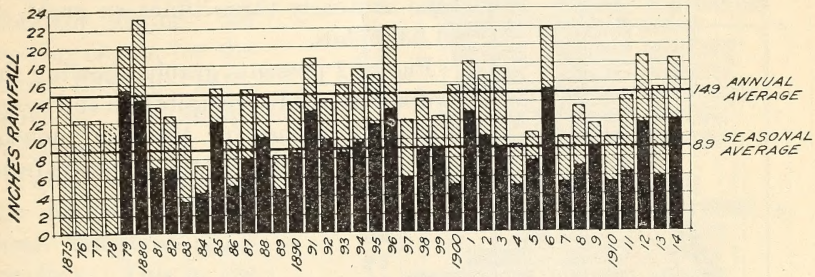

FIG. 1.—Diagram showing the precipitation at Williston, N. Dak.: Annual and average for the 40-year period from 1875 to 1914, inclusive (shaded columns); seasonal (April to July) for the 36-year period from 1879 to 1914, inclusive (solid black columns).

rainfall for the growing season and the upper horizontal line the average annual precipitation for the 36 years included in Table I.

EVAPORATION.

Table II shows the monthly precipitation and monthly evaporation during the growing season (April to July, inclusive) for the six years from 1909 to 1914, inclusive. The evaporation as well as the precipitation is an important controlling factor on the growth of crops in the entire Great Plains area. The evaporation is determined from a free water surface, the method being the one generally in use where the Biophysical Laboratory of the Bureau of Plant Industry has been cooperating.[1]

TABLE II.—*Monthly precipitation and evaporation at the Williston substation for the growing season, 1909 to 1914, inclusive.*

[Data (in inches) from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	Apr.		May.		June.		July.		Total.	
	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.
1909	0.64	3.000	2.84	6.466	3.72	5.173	1.72	6.018	8.90	20.657
1910	1.40	5.340	1.30	5.764	1.65	8.171	1.27	8.994	5.62	28.269
1911	.32	5.790	3.00	6.087	1.37	7.145	1.40	8.717	6.09	27.739
1912	2.13	3.875	4.59	4.781	1.59	6.468	3.60	5.980	11.91	21.104
1913	.15	4.432	1.05	5.229	2.15	7.676	2.60	7.154	5.95	24.491
1914	.49	3.866	1.31	5.603	7.98	5.289	2.32	7.162	12.00	21.920
Average	.86	4.384	2.35	5.655	3.08	6.654	2.15	7.337	8.43	24.030

[1] Briggs, L. J., and Belz, J. O. Dry farming in relation to rainfall and evaporation. U. S. Dept. Agr., Bur. Plant Indus. Bul. 188, p. 16–20, 1910.

Table II shows that for no month during the six years does the precipitation exceed the evaporation from a free water surface. The average monthly precipitation for the six years is shown to be greatest during June, 3.08 inches. The average evaporation during June for the same period of years is 6.65 inches, or more than twice the rainfall. The average rainfall for the four months (April to July) during the six years is 8.43 inches, and the evaporation for the same period of time is nearly three times as great, or 24.03 inches.

Figure 2 presents graphs showing the average monthly precipitation and evaporation in inches for the four months from April to July for the six years from 1909 to 1914, inclusive.

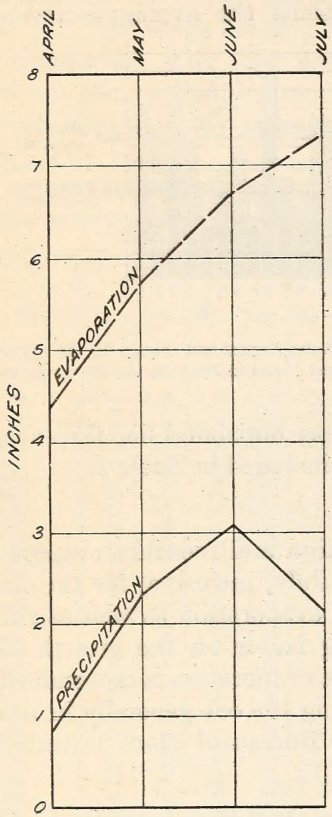

FIG. 2.—Graphs showing the average monthly precipitation and evaporation during the growing season (April to July, inclusive) at Williston, N. Dak., 1909 to 1914, inclusive.

WIND.

The average monthly wind velocity for the six years from 1909 to 1914, inclusive, is shown in Table III.

TABLE III.—*Average wind velocity at the Williston substation, by months, for the growing season, 1909 to 1914, inclusive.*

[Data (in miles per hour) from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	Apr.	May.	June.	July.	Average.
1909	.....	.....	7.0	5.8	.....
1910	8.7	8.0	7.0	5.7	7.4
1911	8.8	8.6	6.9	6.1	7.6
1912	7.2	7.9	6.1	3.8	6.3
1913	8.1	6.5	6.3	4.2	6.0
1914	6.6	7.1	4.9	3.5	5.5
Average	7.9	7.6	6.4	4.9	6.6

The anemometer used at Williston stands about 2 feet from the surface of the ground and near the evaporation tank. Table III shows that the average wind velocity from April to July is 6 miles per hour. It also may be seen that generally there is a decrease in the velocity of the wind each month from April to July. In seasons of normal rainfall protracted hot winds are not common. In seasons of unusually low precipitation hot winds may prevail, as was the case in 1910, when successive hot winds occurred for a period of about four days in June, practically ruining the small-grain crops.

TEMPERATURE.

The daily variations in temperature at Williston are recorded automatically by a thermograph. These records are checked by the use of maximum and minimum thermometers. The mean, maximum, and minimum temperatures, by months, during the growing season for the years 1909 to 1914, inclusive, are shown in Table IV.

Table IV shows that the highest monthly mean temperature is for July. This is the only month that a minimum lower than 32° F. has not occurred in some one of the six years.

The frost-free period is shown in graphic form in figure 3, covering a period of 33 years (1882 to 1914). It shows that the average date of the last killing frost in the spring is May 18 and that the average date of the first frost in the autumn is September 14. The shortest period between frosts, as shown by the graph, was 80 days (in 1883) and the longest period was 155 days (in 1905). The average frost-free period for the 33 years is 119 days.

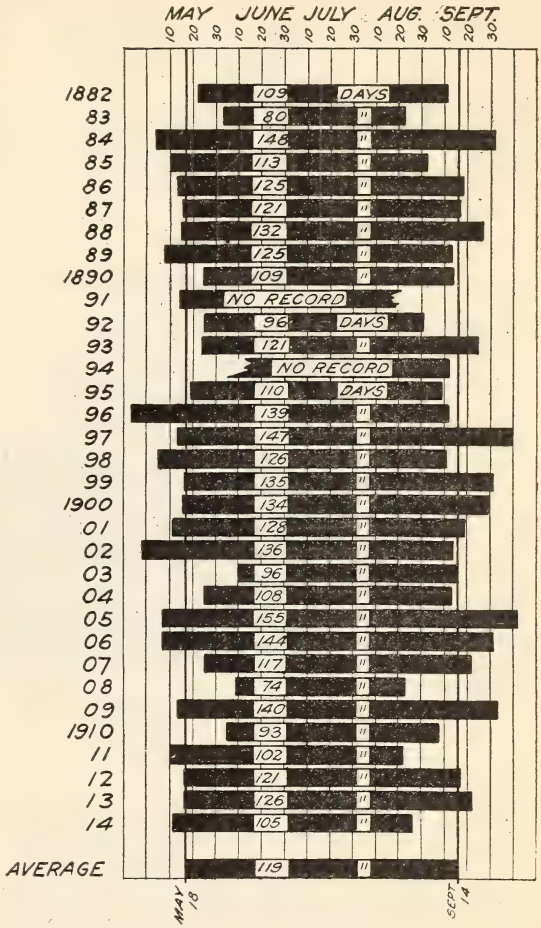

FIG. 3.—Diagram showing the length of the frost-free period and the average dates of the last killing frost in spring and the first in autumn for the 33-year period from 1882 to 1914, inclusive, at the Williston substation.

Previous to 1893, the temperature records were kept at Fort Buford and since that date at Williston.

TABLE IV.—*Summary of mean, maximum, and minimum temperatures at the Williston substation, by months, for the growing season, 1909 to 1914, inclusive.*

[Data (in °F.) from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	Apr.			May.			June.			July.			Seasonal mean.
	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	
1909	35	62	9	51	86	20	61	91	40	67	94	47	54
1910	50	92	12	51	81	25	67	105	32	68	104	43	59
1911	42	89	12	56	90	15	68	100	43	65	99	38	58
1912	45	68	19	54	85	31	64	99	32	65	90	38	57
1913	47	89	19	52	95	22	67	95	41	67	93	40	58
1914	48	79	10	54	86	20	62	92	39	73	100	44	59
Average	45	.....	.....	53	.....	.....	65	.....	.....	68	.....	.....	58

EXPERIMENTAL METHODS.

In all the varietal tests at Williston the primary objects have been to determine the relative yielding powers of the varieties and to increase the yield and quality through the selection of standard varieties or the importation of new ones.

The work has been conducted along the two lines usual on experiment farms: (1) Testing in field plats under conditions that conform as closely as possible to farm practices, and (2) testing in nursery rows, where a very much larger number of varieties or races can be grown more economically than is possible in large plats.

The work of testing and improving cereals has included both spring and winter varieties, but the greater part of the work has been with spring cereals

PLAT EXPERIMENTS.

DIMENSIONS OF PLATS.

The field tests were conducted on plats approximately one-twentieth of an acre in area. The plats have varied slightly each year in size and shape, but all plats were uniform in size for each year. The approximate dimensions have been 8 feet wide (the width of the drill used) and 272¼ feet long, but in some years they were longer and narrower and in other years they were shorter, making an area slightly more or less than one-twentieth of an acre. The alleys between the plats have been 18 inches wide. A general view of the plats is shown in figure 4

TREATMENT OF PLATS.

In 1908, the first year during which the Williston substation was operated, all of the field plats were located on old ground that had borne oats the previous year. The following two years, 1909 and 1910, the varietal plats were located on new ground and were therefore in a different location each year. In each case, the virgin soil

was broken in June of the previous year. After breaking to a depth of 6 inches, the ground was disked and harrowed and kept free from weeds during the remainder of the season.

In 1911 the varieties were grown on ground that produced a corn crop the previous year. In 1912 the plats were on breaking, as in 1909 and in 1910. In 1913 and 1914 they were on summer-fallowed ground.

In the spring of each year the ground was worked sufficiently to put it in good condition for seeding. It was disked when necessary and was harrowed two or more times. In the case of fallow, harrowing or disking was done frequently enough to keep down all weed growth throughout the season. The plats were given no further cul-

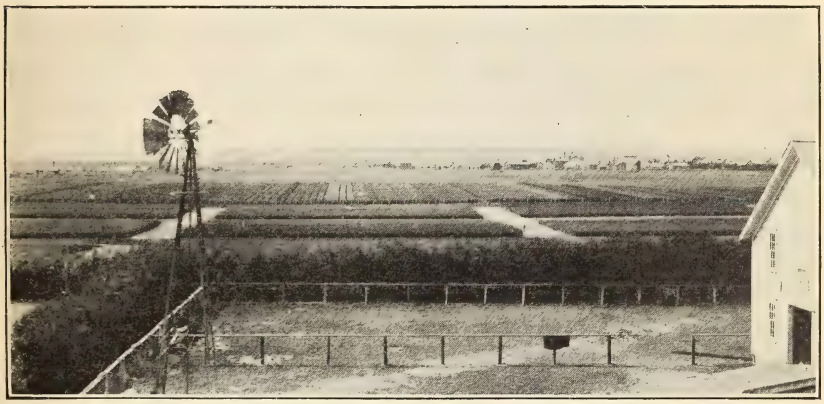

FIG. 4.—View at the Williston substation in 1914, showing the long, narrow plats of cereal varieties in the background.

tivation after seeding, but the alleys between were kept free from weeds.

TREATMENT OF CROPS.

The seeding has been done with a double-disk 8-foot drill with a 6-inch spacing between the disks. The wheat and oats were seeded usually during the last part of April, and the barley and flax somewhat later. With the exception of flax, which should not be sown very deep, the small grains were seeded from 2 to 3 inches in depth. The seeding in each case was at the rate which was considered best for the locality.

After the crops headed they were freed from mixtures by roguing. The cutting was done with a binder and the bundles placed in shocks, where they remained until thrashed. Thrashing has been done with a small separator with a 12-inch cylinder. Great care was used to avoid the mixing of varieties in harvesting and thrashing.

PLAT RECORDS.

The first note taken after emergence was of the comparative stand. Since seeding was uniform for each cereal or comparable group of varieties, uniform stands of plants could be expected when the germination was perfect. However, these conditions were noted after the plants emerged and a comparison of stands of the different plats was taken.

Other important notes were recorded throughout the season, such as dates of heading, ripening, and cutting. If smut, rust, or other diseases were present, such data were recorded.

As each variety was thrashed the weight of the grain from the plat was recorded. This weight was then divided by the standard bushel weight and the yield in bushels per acre determined.

Previous to 1912 the varieties of cereals were grown in single plats without checks. In 1912 and 1913 check plats were used. In 1914 all varieties of cereals were sown in duplicate fiftieth-acre plats.

SOURCE OF THE SEED.

The cereals grown in the plat tests have come from many different sources. The first year nearly all of the seed was obtained from the North Dakota Agricultural Experiment Station or from the Edgeley substation. Since that time varieties have been obtained from various sources in North Dakota and in other States, and also from foreign countries having a climate similar to that of the northern Great Plains area. Promising varieties from the cereal nursery also have been increased and grown in the field tests.

NURSERY EXPERIMENTS.

Many varieties and races of cereals have been tested in nursery rows. This method has permitted work with a much larger number of varieties here than in the larger plats. The ground used each year was usually cultivated land that had borne potatoes or corn the previous year. In this way the land was kept free from volunteer grain. Special care was given to the selection of uniform soil, to uniformity in the rate of seeding, and to the spacing and length of rows. More detailed notes were made throughout the season than were taken of the varietal plats under field conditions.

The nursery consisted of centgeners, head rows, and rod rows. In 1908 it was planted entirely in centgeners, from each of which the best plant was selected each year for planting the following year. The number of centgeners decreased each year until 1912, after which this method was discarded. In 1909 the use of head rows and rod rows was begun, and in 1913 these entirely replaced the centgeners.

Table V shows the number of centgeners, head rows, and rod rows planted each year since 1908. The number of rows of winter wheat grown each year since 1911 is shown separately. The winter-wheat rows have been 1 rod long or shorter.

TABLE V.—*Number of plantings of spring and winter cereals in centgeners and in rows at the Williston substation, 1908 to 1914, inclusive.*

Year.	Spring cereals.			Winter wheat rows.	Year.	Spring cereals.			Winter wheat rows.
	Cent-geners.	Head rows.	Rod rows.			Cent-geners.	Head rows.	Rod rows.	
1908	156	.....	.....	.....	1912	53	343	507	125
1909	107	87	359	.....	1913	.....	500	180	100
1910	111	426	339	.....	1914	.....	546	175	75
1911	55	280	200	90					

CENTGENERS.

In 1908 there were 156 centgener plats. The number decreased each year until 1913, when centgeners were discontinued. The centgener plats were planted in squares with one seed in a place, the seeds being 4 inches apart each way. Each centgener was sown with seed from a single plant. A complete centgener contained 100 seeds, if a plant produced that number. Around the outside of the plat two rows of some other variety were sown for protection.

The best plant in each centgener plat each year was selected for planting the following year. All inferior plants were discarded. The plant selected for continuing the centgener was the one which approached most nearly the standard sought.

HEAD ROWS.

The head rows are 5 feet in length and 12 inches apart. The seeds are spaced 3 inches apart in the row, thus requiring 20 seeds for each row.

The material tested in head rows came from various sources. Much of it was in the form of individual heads chosen from the varietal plats of wheat, oats, and barley, or from farm fields. Each such head was planted in a head row.

When the work was begun, it was thought that improvement would result from continuous selection within a pure line. The best plant was selected each year from the head row, just as in the centgener, and its seed sown the following year. This plan was abandoned in 1912. Thereafter a race was kept in the head row but a single year. If inferior, it was discarded. If promising, a rod row was sown the following year with bulk seed from the head row. Notes were taken throughout the season on heading, ripening, yields, and such other factors as were considered essential to proper comparisons.

ROD ROWS.

Previous to 1912 the rod rows were planted by opening a furrow, distributing the seed as uniformly as possible by hand, and then covering the rows. In 1912 each row was planted with 210 seeds 1 inch apart in the row. These rows were 17½ feet long, but the plants from 6 inches at each end of the row were discarded to reduce as much as possible the border effect. Only 16½ feet were harvested.

The writer has devised a planter for placing the seeds at uniform intervals in the row. This device, which was first used in 1912, is fairly satisfactory as compared with the method formerly used in planting. The planting device consists of a V-shaped trough 17½ feet long made in two sections of 8¾ feet each. It is made of boards 3 inches wide and 1 inch thick. Transverse grooves were made 1

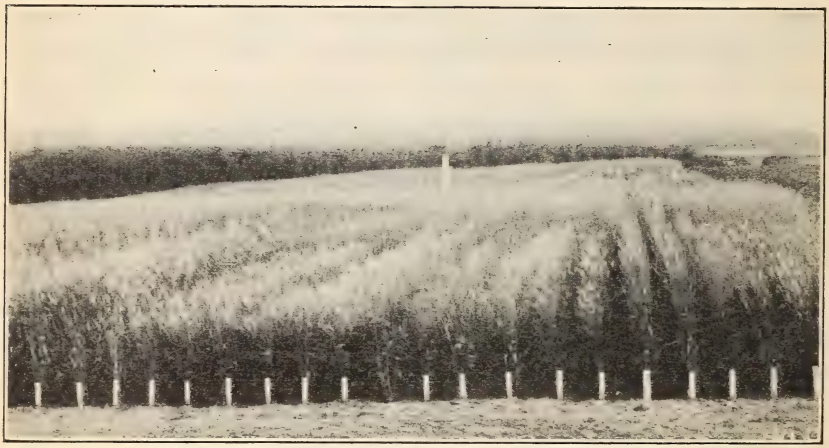

FIG. 5.—View of the cereal nursery at the Williston substation in 1912.

inch apart on the inside of one wing of the trough. A seed is placed in each of the notches and remains in its position until the planter is tipped into the opened furrow. Each of the 210 seeds then rolls down the groove and drops into position in the row.

The trough may be raised on supports 3 or 4 feet from the ground while the seeds are being placed in the grooves. The seeds are placed in the grooves quite rapidly by shaking them from the open end of an envelope held in the hand. Those that fall out of place are quickly moved with a pair of tweezers.

The row is opened with a small hand plow. The trough with seeds in place is then lifted from its supports, the seeds turned into the opened furrow, and then covered. Very uniform stands have been obtained in all rows during the years the planter has been used.

The rod rows have contained sowings of the varieties used in field tests, newly imported cereals obtained through the Office of Cereal

Investigations, selected pure races from the head-row tests, and any other samples desired for comparison with standard varieties. When promising varieties were discovered, they were increased and placed in the field-plat tests. Taganrog durum wheat (C. I. No. 1570) and a pure line of Manchuria barley (C. I. No. 882) are good examples.

Figure 5 shows a portion of the cereal nursery at Williston in 1912.

EXPERIMENTS WITH WHEAT.

In the Williston district, spring wheat is grown almost exclusively. Winter wheat has been tried in northwestern North Dakota and adjoining portions of Montana, but with poor results. In most years the winterkilling has been very heavy, and sometimes all the plants have been killed. Occasionally the crop has been quite successful, with little or no winterkilling, giving better results than spring wheat for those particular years. The tests at the Williston substation thus far have shown that winter wheat has not been a dependable crop.

SPRING WHEAT.

The spring wheats of the North-Central States belong to one or the other of two subspecies of wheat, durum and common. The common subspecies include the three groups, fife, bluestem, and preston, as well as a few miscellaneous varieties.

The spring-wheat varieties have been grown each year on newly broken land, on corn ground, or on fallow. When there were indications of the presence of smut the seed has been treated before sowing. Until 1911 the rate of seeding had been 5 pecks of common wheat and 6 pecks of durum wheat per acre. Since that time they have been seeded at the rate of 4 pecks for common and 5 pecks for durum wheat. In the rate-of-seeding tests this latter rate has been found to give as good results as heavier seeding.

The annual yields produced by all the varieties of spring wheat grown at Williston during the seven years (1908 to 1914) are given in Table VI. The varieties are arranged in five groups, according to their relationships. The groups appear in the table in the order of their importance in this locality. Of the 35 varieties grown during the seven years, only 20 were grown in 1914. Seven varieties have been grown for all of the seven years. Table VI also shows the average yield of each variety for the years during which it has been grown.

The average annual yields of the different groups are shown in Table VI for each of the years from 1908 to 1914. The durum group made the highest yield in five out of the seven years. In 1910 the durum group yielded lower than any other, and in 1911 it yielded lower than any other except the bluestem and the miscellaneous groups.

TABLE VI.—*Annual and average yields, by groups, of 35 varieties of wheat grown at the Williston substation, 1908 to 1914, inclusive.*

Group, Cereal Investigations number, and variety.	Yield per acre (bushels).							
	1908	1909	1910	1911[a]	1912	1913	1914	Average.
Durum group:								
1494, Arnautka (N. Dak. No. 778)	10.6	32.0	.....	.....	.....	.....	.....	21.3
3693, Arnautka	15.6	37.4	6.1	8.2	49.7	34.7	47.2	28.4
4064, Arnautka 6 P 4	.....	.....	.....	.....	.....	.....	50.0	50.0
3657, Australian	.....	.....	.....	.....	.....	.....	49.6	49.6
1443, Gharnovka (N. Dak. No. 917)	11.0	37.1	.....	.....	.....	.....	.....	24.1
1447, Gharnovka	15.8	35.5	9.3	10.5	46.0	34.8	.....	25.3
1447, Gharnovka (selection)	.....	.....	.....	.....	.....	31.0	.....	31.0
1440, Kubanka	12.6	39.1	11.0	8.9	51.0	33.0	53.8	29.9
4063, Kubanka No. 8	.....	.....	.....	.....	.....	.....	45.0	45.0
2086, Pelissier (selection)	.....	.....	.....	.....	.....	25.3	.....	25.3
1350, Pererodka	12.8	34.8	9.5	7.3	48.3	33.7	.....	24.4
1570, Taganrog (selection)	.....	.....	.....	.....	.....	35.0	54.6	44.8
1445, Velvet Don	15.6	36.8	3.7	8.9	43.3	25.0	.....	22.2
Average	13.4	36.1	7.9	8.8	47.7	31.6	50.0	.....
Fife group:								
1517, Ghirka Spring	.....	33.2	20.2	12.1	51.7	22.2	40.4	30.0
2873, Glyndon (Minn. No. 163)	9.8	31.2	13.9	8.0	44.7	28.2	49.2	26.4
3641, Marquis	.....	.....	.....	.....	.....	29.0	52.5	40.8
Power (N. Dak. No. 312)	11.9	([b])	12.4	.....	.....	.....	.....	12.2
Power (N. Dak. No. 317)	14.0	([b])	11.0	.....	.....	.....	.....	12.5
3697, Power (N. Dak. No. 313)	13.1	34.0	17.1	11.1	44.7	[c]28.7	51.3	28.6
3694, Red Fife (N. Dak. No. 646)	11.3	34.2	14.9	10.2	46.0	28.7	47.9	27.6
Average	12.0	33.2	14.9	10.4	46.8	27.4	48.3	.....
Preston group:								
3328, Preston (Minn. No. 188)	.....	.....	.....	.....	.....	.....	47.2	47.2
3692, Preston (N. Dak. No. 2393)	.....	.....	9.1	10.2	45.5	26.7	.....	22.9
3698, Preston	.....	26.2	13.4	12.7	44.7	25.0	46.3	28.1
Average	.....	26.2	11.3	11.5	45.1	25.9	46.8	.....
Bluestem group:								
3314, Crossbred (N. Dak. No. 318)	11.2	31.0	12.4	[d]4.9	43.0	.....	.....	20.5
3083, Dakota (N. Dak. No. 316)	16.7	35.1	11.1	10.9	42.3	30.7	47.5	27.8
3021, Haynes (Minn. No. 51)	14.2	35.9	11.0	9.2	42.3	29.2	46.3	26.9
2874, Haynes (Minn. No. 169)	10.5	34.3	8.8	.....	44.3	30.0	42.5	28.4
Haynes (selection)	.....	.....	.....	9.0	.....	.....	.....	9.0
3082, Marvel (N. Dak. No. 722)	13.0	35.9	11.0	[d]3.8	41.0	.....	.....	20.9
Average	13.1	34.2	10.9	7.6	42.6	30.0	45.5	.....
Miscellaneous group:								
2398, Galgalos	.....	.....	.....	.....	.....	27.7	.....	27.7
3690, Humpback (N. Dak. No. 2365)	.....	.....	12.4	8.9	41.7	30.0	.....	23.3
3315, Huron	.....	.....	.....	.....	.....	.....	52.2	52.2
2492, Manchuria	.....	.....	.....	.....	.....	19.7	46.7	33.2
3008, Wolkoren	.....	.....	.....	.....	.....	.....	42.7	42.7
3700, World Beater	.....	.....	.....	4.9	40.7	27.0	38.8	27.9
Average	.....	.....	12.4	6.9	41.2	26.1	45.1	.....
Summary of averages:								
Durum group	13.4	36.1	7.9	8.8	47.7	31.6	50.0	.....
Fife group	12.0	33.2	14.9	10.4	46.8	27.4	48.3	.....
Preston group	.....	26.2	11.3	11.5	45.1	25.9	46.8	.....
Bluestem group	13.1	34.2	10.9	7.6	42.6	30.0	45.5	.....
Miscellaneous group	.....	.....	12.4	6.9	41.2	26.1	45.1	.....

[a] All varieties in 1911 were slightly damaged in the shock by hail.
[b] Yields lost.
[c] Average of 3 plats.
[d] Not comparable with other yields for 1911.

Of the common wheats, the bluestem group was highest in yield in 1908, 1909, and 1913, the fife group was highest in 1910 and 1912, and the preston group in 1911 and 1914.

A summary of the yields of twelve standard varieties of wheat at Williston is given in Table VII. Seven of these varieties have been tested for the entire period of seven years, two for six years, and three for only two years. The average yields for each of these three periods are shown. The varieties in Table VII are arranged according to these groups.

TABLE VII.—*Annual and average yields of 12 varieties of spring wheat grown at the Williston substation for three different series of years between 1908 and 1914.*

Group, Cereal Investigations number, and variety.	Yield per acre (bushels).									
								Average.		
	1908	1909	1910	1911	1912	1913	1914	1908 to 1914.	1909 to 1914.	1913 and 1914.
Durum group:										
1440, Kubanka	12.6	39.1	11.0	8.9	51.0	33.0	53.8	29.9	32.8	43.4
3693, Arnautka	15.6	37.4	6.1	8.2	49.7	34.7	47.2	28.4	30.6	41.0
1570, Taganrog	.....	.....	.....	.....	.....	35.0	54.6	.....	.....	44.8
Fife group:										
3697, Power	13.1	34.0	17.1	11.1	44.7	28.7	51.3	28.6	31.2	40.0
3694, Red Fife	11.3	34.2	14.9	10.2	46.0	28.7	47.9	27.6	30.3	38.3
2873, Glyndon (Minn. No. 163)[1]	9.8	31.2	13.9	8.0	44.7	28.2	49.2	26.4	29.2	38.7
1517, Ghirka	.....	33.2	20.2	12.1	51.7	22.2	40.4	.....	30.0	31.3
3641, Marquis	.....	.....	.....	.....	.....	29.0	52.5	.....	.....	40.8
Preston group:										
3698, Preston	.....	26.2	13.4	12.7	44.7	25.0	46.3	.....	28.1	35.7
Bluestem group:										
3083, Dakota (N. Dak. No. 316)	16.7	35.1	11.1	10.9	42.3	30.7	47.5	27.8	29.6	39.1
3021, Haynes (Minn. No. 51)	14.2	35.9	11.0	9.2	42.3	29.2	46.3	26.9	29.0	37.8
2874, Haynes (Minn. No. 169)	.....	.....	.....	.....	.....	30.0	42.5	.....	.....	36.3

[1] Previous to 1911 the Glyndon variety was grown from seed originally obtained from the Edgeley substation in North Dakota; in 1911 and succeeding years it was grown from seed originally from the Minnesota Agricultural Experiment Station.

For the period of seven years the Kubanka durum wheat (C. I. No. 1440) made the highest yield, 29.9 bushels per acre. The Power fife wheat was second in yield, with an average of 28.6 bushels. These varieties also led for the 6-year period (1909 to 1914), during which the Ghirka (C. I. No. 1517) and the Preston (C. I. No. 3698) were included. Figure 6 shows graphically the annual and average yields of the leading varieties within the four different groups for the six years from 1909 to 1914, inclusive.

In 1913 the Taganrog (C. I. No. 1570), Marquis (C. I. No. 3641), and Haynes (C. I. No. 2874) were added to the test. The averages for 1913 and 1914 show that in the durum group the Taganrog variety yielded more than the Kubanka, and that in the fife group the Marquis variety was better than the Power.

The average dates of heading and of ripening, number of days from planting to heading and to maturity, height, yield per acre, and weight per bushel of grain for the varieties grown during the 6-year period (1909 to 1914) are shown in Table VIII. Figure 7 shows heads of eight representative varieties of the four groups of spring wheat.

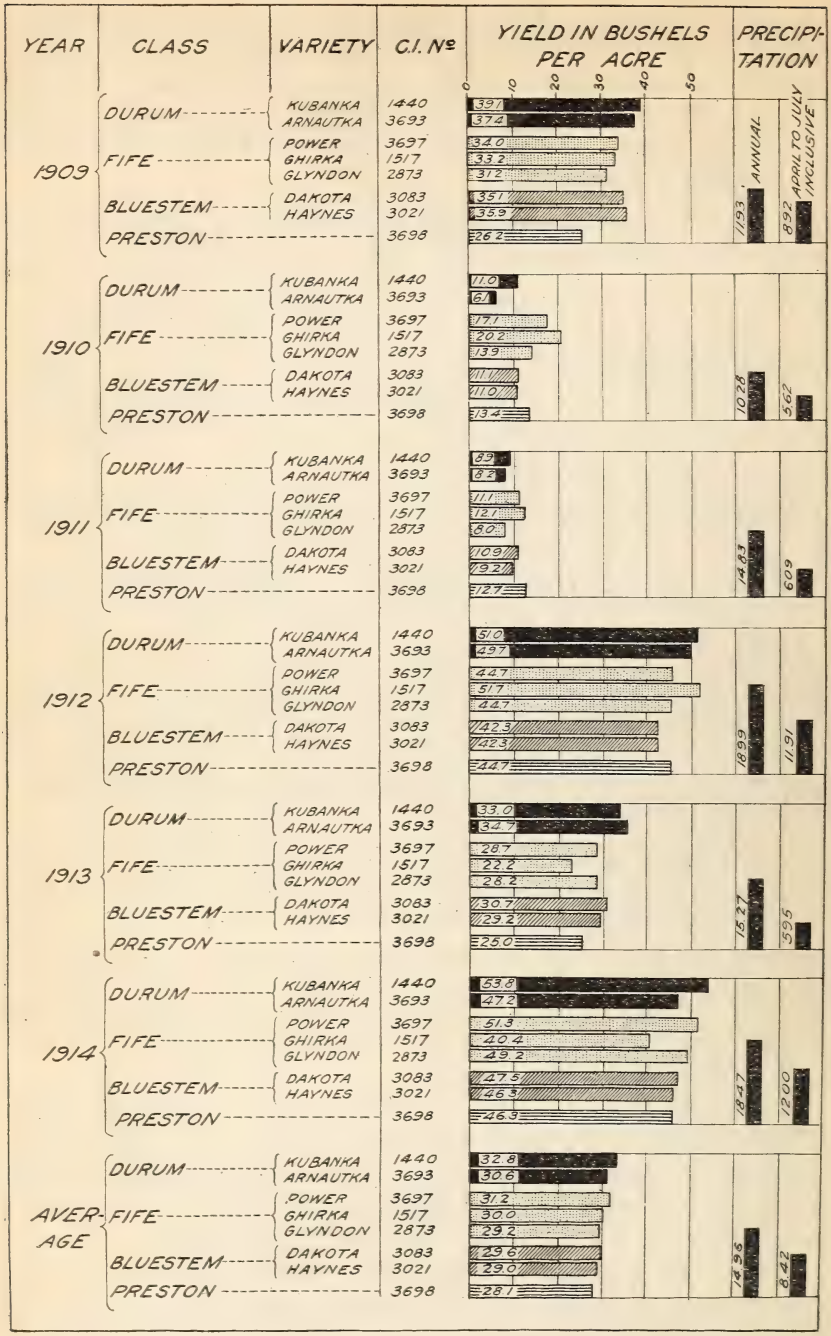

FIG. 6.—Diagram showing the annual and average yields of leading varieties in four different groups of spring wheat at the Williston substation, with data on the annual and seasonal precipitation for the six years from 1909 to 1914, inclusive.

TABLE VIII.—*Average growth data, yields per acre, and weight of grain per bushel for nine varieties of wheat at the Williston substation, 1909 to 1914, inclusive.*

Group, Cereal investigations number, and variety.	Average date.		To maturity from—		Height.	Yield per acre.	Weight per bushel.
	Headed.	Ripe.	Planting.	Heading.			
			Days.	*Days.*	*Inches.*	*Bushels.*	*Pounds.*
Durum group:							
1440, Kubanka	July 8	Aug. 3	105	26	39	32.8	62.0
3693, Arnautka	...do	...do	105	26	39	30.6	61.5
Fife group:							
3697, Power	July 11	Aug. 4	107	24	35	31.2	60.8
3694, Red Fife	...do	...do	106	24	36	30.3	58.6
2873, Glyndon (Minn. No. 163)	July 13	...do	107	22	35	29.2	58.2
1517, Ghirka	July 7	July 30	102	23	35	30.0	60.7
Preston group:							
3698, Preston	July 11	Aug. 2	103	22	35	28.1	60.7
Bluestem group:							
3083, Dakota (N. Dak. No. 316)	July 13	Aug. 6	108	24	37	29.6	57.4
3021, Haynes (Minn. No. 51)	...do	...do	107	24	37	29.0	57.1

Table VIII shows that the date of heading is earlier for the durum than for the other groups, but they require a longer period from heading to maturity and ripen at about the same time. They also

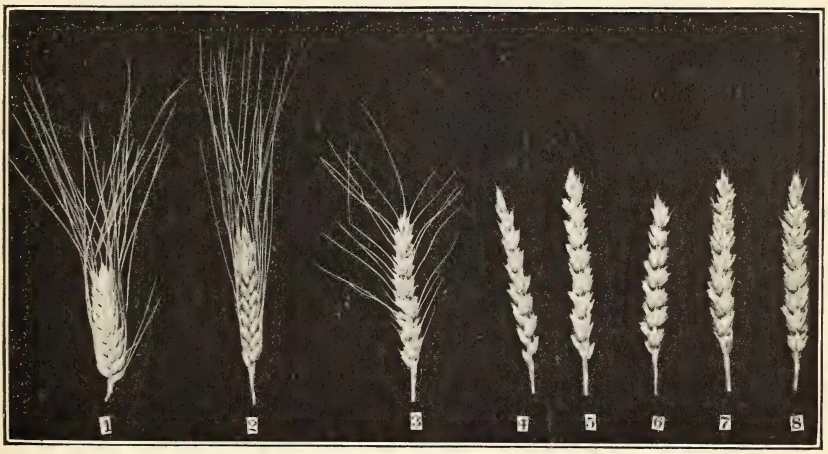

FIG. 7.—Heads of representative varieties of the four groups of spring wheat grown at the Williston substation: Durum group—Kubanka (1) and Arnautka (2); preston group—Preston (3); fife group—Ghirka (4), Rysting (5), and Marquis (6); bluestem group—Crossbred (7) and Haynes (8).

grow tallest and have the heaviest bushel weight. The Ghirka and the Preston are the earliest maturing varieties. The bluestem varieties head and ripen later than the varieties of the other groups. They also have the lowest bushel weight.

DURUM GROUP.[1]

Durum wheat was introduced into the United States from Russia in 1899 by Mr. Mark Alfred Carleton, Cerealist of the United States Department of Agriculture. The durum wheats have rather long, tough straw and large, heavy, bearded heads. The kernels also are large and the bushel weight is high. The grains are held very tightly within the glumes, thus enabling them to stand without shattering for some time after becoming ripe. Because of the weight of the heads, they have a tendency to droop over as the grain ripens, which makes the durums more difficult to cut with a binder than the fife and bluestem wheats.

In 1910 and 1911 the yields of the durum wheats were lower than those of the other groups. These two years were characterized by low rainfall and high evaporation during the growing season. In 1911 no protracted hot winds occurred, but in 1910 there were several days of continuous hot winds about the time wheat was heading. There was a normal growth of straw and heads each year, but a large percentage of the heads contained no kernels. This condition seemed to be peculiar only to the durum group.

Kubanka.—The Kubanka variety of durum wheat was introduced from Russia by the United States Department of Agriculture in 1899. It has a stout, rather broad head with yellowish, glabrous glumes and long yellow beards. Of the several durum varieties that have been tested at Williston, the Kubanka has given the best results, with the Arnautka second. Table VII shows that the Kubanka has the highest average yield of any variety for the 7-year period (1908 to 1914) or for the 6-year period (1909 to 1914). For the two years 1913 and 1914 it has given better yields than any other except the Taganrog (C. I. No. 1570).

Taganrog.—The Taganrog variety (C. I. No. 1570) closely resembles the Arnautka in having a slightly longer head than the Kubanka. In other respects the three varieties are very similar in appearance. The Taganrog appeared to be promising in the row tests in the cereal nursery, so it was increased and finally added to the field tests in 1913. For each of the years 1913 and 1914 it produced the highest yield of any of the wheats tested.

FIFE GROUP.

The varieties of the fife group are beardless and the glumes glabrous. They head and ripen a little earlier than the bluestems, as is shown in Table VIII. This is especially true of the Ghirka. Their height is somewhat less and the bushel weight considerably more than the average bluestems.

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[1] For a more complete discussion and history of the wheat groups and their varieties see the following: Clark, J. A. Cereal experiments at Dickinson, N. Dak. U. S. Dept. Agr. Bul. 33, 44 p., 7 fig., 1 pl., 1914. Salmon, Cecil, and Clark, J. A. Durum wheat. U. S. Dept. Agr. Farmers' Bul. 534, 16 p., 4 fig., 1913.

The fife wheats have proved superior in most points to the bluestem group for the territory surrounding Williston. One of the principal points in their favor is that they do not shatter so badly when fully ripe. The tests made at Williston show that the quality of the fife grain is ordinarily better than that of the bluestem group.

Power.—The Power variety is a selection from the original Red Fife. It is said to have originated about 1885 with Mr. James Holes, of Fargo, N. Dak., from a single plant. It was increased and distributed in large quantities by Mr. J. B. Power, of Power, N. Dak.; hence the name. Seed from Mr. Power was given the number 66 by the experiment stations of both North Dakota and Minnesota. Later selections from Minnesota No. 66 were given the Minnesota numbers 149 and 276.

The average yield of Power fife (C. I. No. 3697) for the six years (1909 to 1914) has been 31.2 bushels per acre, as shown in Table VII. This is the highest yield made by any variety of common wheat tested at Williston for the same period. Power fife also has had the highest bushel weight of any variety tested except the durums, as shown in Table VIII.

Ghirka Spring.—The Ghirka wheat (C. I. No. 1517) came from Russia. It seems to possess better drought-resisting qualities than any of the other fifes or any of the bluestems tried at Williston. This quality was very noticeable during the two dry years, 1910 and 1911. In 1910 the yield of Ghirka exceeded that of any other wheat tested that year, and in 1911 it stood second in yield.

In 1910 and 1911 the heads of Ghirka filled completely to the tips, while the other fifes and bluestems did not. Ghirka has a longer, more tapering head than the other varieties of the fife group. The kernel of the Ghirka is larger than that of the other fifes or of the bluestems, but it is not as hard, and the milling quality is somewhat inferior.

Marquis.—The Marquis variety (C. I. No. 3641) was derived from a cross made in Canada between a hard red Calcutta wheat and Red Fife. This wheat is of comparatively recent origin and distribution. While grown for several years on the Dominion experiment farms in Manitoba, Saskatchewan, and Alberta, it has been in the tests at Williston but two years. During this time it has given results about equal to those from Power fife.

The growth of straw is shorter than that of the other fifes; the head also is shorter, and the grain is held more firmly within the glumes. The kernels are short, very plump, and the weight per bushel is good.

PRESTON GROUP.

The wheats placed together in the somewhat variable preston group are all bearded, with glabrous glumes and hard red kernels much like those of the fife group. In some of the varieties the milling

and baking qualities are similar, and in others they are somewhat inferior to the fifes. Some of the varieties have been known commercially as "velvet chaff." This name is unfortunate, since none of them have pubescent glumes. The preston wheats possess somewhat better drought-resistant qualities than those of either the ordinary fife or bluestem groups.

Preston.—The Preston variety (C. I. No. 3698) originated as a hybrid at Ottawa, Canada, about 1893, from a cross of Ladoga and Red Fife. It was selected there for earliness and stiff straw. It is the leading variety of this group. Its average yield for the six years (1909 to 1914) has not been as high as those of the other wheats shown in Table VII. It made a better yield than the bluestems, however, in the dry year 1910. In 1911, a second dry year, its yield was higher than that of any other wheat shown in Table VII.

BLUESTEM GROUP.

The bluestem group is composed of varieties with beardless heads and pubescent glumes. The bluestems head and ripen a little later than the fifes. At Williston they have yielded less than the fifes and their weight per bushel has been lower. Table VIII shows that the average weight per bushel falls below 58 pounds.

Bluestem wheat has been considered one of the best hard spring wheats to grow in the North-Central States. It possesses qualities that give it a high place as a bread wheat. The trials at Williston have shown that for that district it is inferior to the fife and durum groups in yield and in quality of grain. The weight per bushel has not averaged high enough to insure its being graded as No. 1 northern.

RATE-OF-SEEDING TEST WITH SPRING WHEAT.

An experiment to determine the best rate of seeding for spring wheat was begun in 1911. Dakota Bluestem (C. I. No. 3083) was the variety used. Six rates, varying from 3 to 8 pecks per acre, were tried in 1911. The 8-peck rate was discontinued at the end of that year and the 7-peck rate at the end of 1913. The results obtained are shown in Table IX.

TABLE IX.—*Annual and average yields in a rate-of-seeding test of Dakota Bluestem spring wheat at Williston, N. Dak., 1911 to 1914, inclusive.*

Rate of seeding.	Yield per acre (bushels).					Rate of seeding.	Yield per acre (bushels).				
	1911	1912	1913	1914	Average.		1911	1912	1913	1914	Average.
3 pecks..	1.9	43.7	15.7	41.1	25.6	6 pecks..	2.0	48.0	33.0	48.8	33.0
4 pecks..	2.2	49.0	31.5	47.5	32.6	7 pecks..	2.5	47.6	36.6	.....	.....
5 pecks..	1.7	49.5	30.3	50.4	33.0	8 pecks..	2.0	.....	.....	.....	.....

It will be seen that in none of the years was there any significant difference between the results from the seedings at 4, 5, and 6 pecks. The results from the 3-peck seeding are sufficiently lower to show that 3 pecks is not enough. Since the 4-peck rate gives as good results as the sowing of 5 or 6 pecks and requires less seed per acre, it should be considered the proper rate. The general practice of the farmers in the vicinity of Williston is to sow 4 pecks to the acre.

In each of the years the plat on which the 3-peck rate was seeded was more weedy throughout the season than the plats where the higher rates were used. Owing to the thinner stand of wheat plants in the 3-peck rate, the time from planting to maturity was several days longer each year. The bushel weight of the grain also was less. The average weights per bushel of grain were 56, 55½, 55, and 53½ pounds from the sowings at 6, 5, 4, and 3 pecks, respectively.

NURSERY TESTS OF SPRING WHEAT.

Table X presents certain nursery data for 84 races in the different groups of wheat. These were grown in the 17½-foot rows, planted each year with the planter that placed 210 seeds 1 inch apart in the row. These data are averages for the two years, 1912 and 1913. The same races were used in each of the two years.

The season of 1912 was a very good one for crop production. The rainfall was above normal for the growing period, April to July, inclusive. The season of 1913 was the reverse of 1912. It was exceedingly dry until the latter part of June, and the rainfall from April to July, inclusive, was considerably below normal.

TABLE X.—*Average of miscellaneous data for 84 different races of wheat grown in rod rows at the Williston substation during 1912 and 1913.*

Group and description.	Number of races.	Days to maturity.	Height.	Length of heads.	Stools per plant.	Heads per plant.	Weight of 1,000 kernels.	Yield per row.	
								Straw.	Grain.
Durum group:			*Inches.*	*Inches.*			*Grams.*	*Grams.*	*Grams.*
Smooth glumes	30	106	32.7	2.49	4.29	3.40	41.8	477	311.0
Hairy glumes	9	105	30.1	2.34	4.40	3.71	49.3	466	274.1
Common beardless group:									
Smooth glumes	18	104	36.1	3.55	5.29	4.45	30.7	519	312.1
Hairy glumes	12	104	37.9	3.37	5.60	4.42	26.5	553	306.0
Common bearded group:									
Smooth glumes	15	103	29.1	3.07	5.75	4.77	29.8	459	269.3

In the durum races, as shown by Table X, there were 30 with glabrous and 9 with pubescent glumes. Those with smooth glumes, which include the races of Kubanka and Arnautka, produced the best average yield of grain, 311 grams, compared with 274.1 grams per row from the pubescent-glumed races. The straw also was longer and heavier and the heads longer. The number of tillers, the length of heads, and the kernel weight were lower in the smooth-glumed than in the hairy-glumed races.

In the beardless common wheats there were 18 smooth-glumed and 12 hairy-glumed races. As in the durums, the smooth-glumed races (mostly fifes) produced more grain, longer heads, and fewer tillers per plant than the pubescent-glumed ones (mostly bluestems). The smooth-glumed races also had shorter and lighter straw, more heads per plant, and greater kernel weight than the hairy-glumed races.

In the field plats the fife (glabrous glumes) and the bluestem (pubescent glumes) groups gave similar results in a 6-year average. The fifes had shorter straw and heavier yields of grain, with heavier bushel weight, than wheats of the bluestem group.

WINTER WHEAT.

Winter wheat has been tried at Williston for six years, but the results so far obtained are not favorable. Winter wheat can not be grown here successfully, at least not until some hardier varieties are secured. In 1909, 1910, and 1912 the winter-wheat varieties were on ground that either was newly broken or had been fallowed. The other years they were in corn stubble, the cornstalks having been left standing during the winter.

In the first case the varieties had no protection during the winter except the covering of snow that the plants themselves held, and winterkilling was severe in all three years, with a total loss in 1912. For the three years that the wheat was sown in the standing cornstalks, the spring survival was much higher. Table XI shows the annual and average yields of seven varieties of winter wheat grown during the six years from 1909 to 1914, inclusive.

TABLE XI.—*Annual and average yields of seven varieties of winter wheat grown at the Williston substation, 1909 to 1914, inclusive.*

C. I. No.	Variety.	Yield per acre (bushels).						
		1909	1910	1911	1912[1]	1913	1914	Average.
1543	Beloglina	40.0	9.9	26.5	0	7.8	10.0	15.7
3084	North Dakota No. 1997	26.6	7.3	28.7	0	13.1	15.8	15.3
1583	Kharkof	29.9	7.3	24.9	0	6.8	.....	13.8
3011	Eversole	21.6	9.1	24.9	0	8.4	.....	12.8
3696	Grafton	19.9	7.2	26.1	0	.....	.....	13.3
3699	Reliable	.....	8.7	18.2	0	7.1	.....	8.5
3330	Buffum No. 17	.....	.....	.....	0	15.6	17.1	16.4
	Average	27.6	8.3	24.9	0	9.8	14.3	13.7

[1] The 1912 crop was entirely winterkilled.

The Beloglina (C. I. No. 1543) and an unnamed variety known as North Dakota No. 1997 (C. I. No. 3084) have been found to be the hardiest and best yielding varieties at Williston for the entire period. Both these varieties are of the Crimean or Turkey group of hard red

winter wheats. They have bearded heads and white, glabrous glumes, except that North Dakota No. 1997 has become somewhat mixed and contains some plants with red glumes.

The Beloglina produced an average yield of 15.7 bushels for the six years, and North Dakota No. 1997 yielded 15.3 bushels per acre. The average yield is reduced because of the total killing of the 1912 crop. As previously stated, the plats were on bare ground that year. The Beloglina was sown also in another location between corn rows and the stalks left standing all winter. The spring survival of this plat was good and a yield of 35.1 bushels per acre was harvested. Substituting this yield in the year 1912, when there was no yield from the plat sown on bare ground, would raise the average yield for Beloglina from 15.7 to 21.6 bushels per acre for the six years.

Buffum No. 17 (C. I. No. 3330), introduced into the tests in 1913, gave a higher spring survival in 1913 and 1914 and a higher yield of grain than either Beloglina or North Dakota No. 1997. The heads of Buffum No. 17 are beardless and the glumes are glabrous. In appearance it resembles Ghirka Winter wheat (C. I. No. 1438). The other varieties have bearded smooth-chaffed heads.

With these results with winter wheat at Williston it would seem that a good spring survival can not be had unless the plants have some such protection as cornstalks or grain stubble. To seed on corn ground and leave the stalks standing is too expensive where the corn fodder is valued as highly as it is in the Williston district.

In date-of-seeding trials of winter wheat at Williston it has been found that seeding about the middle of August gives better results than later seeding. If the stubble ground of some spring grain is used for the winter wheat, it is necessary to seed almost as soon as the grain crop can be removed. However, if the autumn is about normal in rainfall, there is likely to be insufficient moisture in the stubble land to germinate the seed.

NURSERY TESTS OF WINTER WHEAT.

Winter wheat has been tested in the nursery at Williston since 1911. Selections have been made from the varieties that have shown the hardiest qualities. Selections also were obtained from hardy varieties at the substations at Moccasin, Mont., and Newell, S. Dak.

Different methods were used in preparing the ground for seeding. Some sowings were made on bare ground, some in standing corn, some in grain stubble, and some by covering the rows lightly with straw. Whenever the rows were protected in any way by a covering of straw or snow, the winterkilling was very slight or there was none at all. Whenever the rows remained without covering, most or all of the plants were killed.

EXPERIMENTS WITH OATS.

The annual and average yields of the varieties of oats that have been grown in plat tests at Williston for the seven years from 1908 to 1914, inclusive, are presented in Table XII. The varieties are grouped in the table according to their date of maturity, the groups being early, midseason, and late. The midseason group is further separated into white, yellow, and black varieties. Of the 38 varieties included in the table, only 17 were grown in 1914.

TABLE XII.—*Annual and average yields per acre of 38 varieties of oats grown at the Williston substation, 1908 to 1914, inclusive.*

Group, Cereal Investigations number, and variety.	Yield per acre (bushels).							
	1908	1909	1910	1911	1912	1913	1914	Average.
Early yellow group:								
459, Kherson							78.9	
165, Sixty-Day	28.8	76.3	4.2	11.2	50.3	45.0	82.2	42.6
165, Sixty-Day (N. Dak. No. 666)	22.3							
Midseason white group:								
731, Abundance (N. Dak. No. 966)	31.3	91.1	12.5	7.7	104.7	93.4	123.9	66.4
Abundance (N. Dak. No. 866)	15.3							
336, Belyak (N. Dak. No. 1425)	14.3	84.0	12.0	6.1	63.8			36.0
733, Big Four (N. Dak. No. 38)	28.0	99.3	9.4	10.0	91.3	62.8		50.1
Big Four (N. Dak. No. 125)	17.9							
444, Canadian						51.2		
734, Early Gothland (Minn. No. 26)	16.4	83.6	13.0	6.1	96.0			43.0
754, Early Mountain						62.5	96.1	79.3
491, Hvitling	29.6	80.6	12.5	9.6	105.0			47.5
736, Hvitling					62.2	58.5	92.2	71.0
492, Ligowo	30.4	104.1	3.6	8.9	98.8			49.2
737, Ligowo (N. Dak. No. 53)	28.3	83.3	9.9	7.7	105.0	76.5		51.8
738, Lincoln (N. Dak. No. 48)	32.1	96.2	15.6	7.0	101.3	84.5	124.3	65.9
Lincoln	14.3							
745, Minnesota No. 202 (N. Dak. No. 802)	28.0	89.2	12.0	7.6	103.2	80.6		53.4
739, Myrick (N. Dak. No. 52)	27.3	90.4	8.9	10.0	107.8	82.5	102.3	61.3
741, Siberian (N. Dak. No. 864)	29.0	104.1	10.9	5.1	106.9	79.4	116.4	64.5
714, Silvermine (N. Dak. No. 723)	37.4	103.3	14.8	7.3	95.7	67.5	120.7	63.8
134, Swedish Select	28.4	86.0	7.8	9.9	84.4	68.8	97.3	54.7
Do						66.3		
742, Victory					88.2	75.6	95.2	86.3
743, White Waverly (N. Dak. No. 997)	11.3	68.0	8.3	5.7	84.4			35.6
Midseason yellow group:								
735, Golden Cluster (N. Dak. 1084)	13.3	104.0	7.8	4.8	108.2	84.5		53.8
493, Golden Rain	14.9						123.3	69.1
494, Probsteier	14.9							
495, Probsteier	36.1	95.0	9.4	6.1	101.3	72.0	112.8	61.8
Midseason black group:								
Black Beauty			9.4	1.3				
766, Black Beauty							82.0	
496, Black Bell	23.8							
497, Great Mogul	23.4							
Late white (side oats) group:								
740, New Zealand (N. Dak. No. 50)	36.1	86.4	8.9	3.5	106.2	82.8		54.0
713, Tartarian (N. Dak. No. 388)	21.4	67.4	11.5	1.3	118.8	83.1	66.8	52.9
732, White Russian (N. Dak. No. 51)	23.0	70.8	13.0	2.9	120.6	80.3	102.0	58.9
744, White Russian (N. Dak. No. 54)	20.6	79.0	11.0	2.2	103.2	76.3	102.4	56.4
White Russian (N. Dak. No. 238)	12.6							

In 1908 and 1911 the oats were seeded on ground that had produced small grain the previous year. In all other years they were grown either on breaking or fallow. The ground each spring was worked into good condition before seeding by harrowing alone or by disking and harrowing.

The seeding was at a rate of 8 pecks per acre from 1908 to 1912, inclusive, 6 pecks per acre in 1913, and 4 pecks per acre in 1914. The rate-of-seeding tests at Williston have shown that the best rate at which to sow oats in that locality is between 4 and 6 pecks per acre. The oats have not been treated for smut every year before seeding, but only when indications of smut were noted.

The only early variety which has been grown more than one year is the Sixty-Day. By far the greater part of the oats grown at Williston belongs to the group here designated as midseason white varieties. These varieties have also produced the best yields. They are decidedly variable as to size of panicle, size and shape of kernel, and other characters, but these differences are not apparent enough to justify further subdivisions into groups at this time.

Of the midseason yellow varieties, only the Probsteier has been grown for the full period, while none of the black oats has been included in the test for more than two years. The late varieties grown at Williston all have one-sided panicles. They have been exceeded in yield by several open-panicled varieties of midseason white oats.

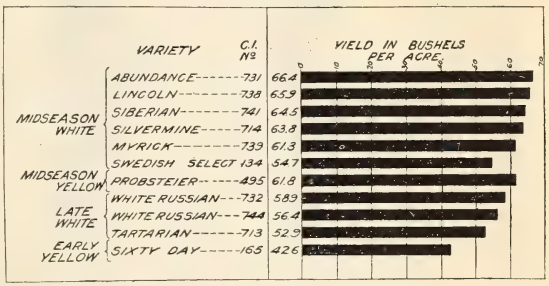

FIG. 8.—Diagram showing the average yields of eleven varieties of oats at the Williston substation, 1908 to 1914, inclusive.

SUMMARY OF OAT YIELDS.

The annual and average yields, the average dates of heading and ripening, the height, and the weight per bushel of the 11 varieties of oats which have been grown for seven years (1908 to 1914) at the Williston substation are shown in Table XIII. The yields are also shown graphically in figure 8. The varieties are arranged in the table and in the graph in the order of their average yields.

Of the varieties included in Table XIII, one (Sixty-Day) may be classed as early, three as late, and the remaining seven as medium or midseason varieties. Heads of four representative varieties are shown in figure 9.

EARLY VARIETIES.

The only early variety of oats which has been grown for the full seven years at Williston is the Sixty-Day (C. I. No. 165). This variety was originally imported from southern Russia by the United States Department of Agriculture in 1901. A similar variety, the Kherson, was imported a few years earlier from the same region by the Nebraska experiment station. The Sixty-Day and Kherson oats are now grown extensively in the corn belt and in the semiarid por-

tions of the United States. At Williston, however, they have given far lower yields than the other varieties under test, and there is no good reason for recommending them for this district unless a very early variety is desired.

FIG. 9.—Heads of four varieties of oats grown at the Williston substation (left to right): 1, White Russian; 2, Siberian; 3, Swedish Select; 4, Sixty-Day.

TABLE XIII.—*Annual and average yields, growth data, and weight per bushel, by groups, of eleven varieties of oats grown at the Williston substation, 1908 to 1914, inclusive.*

Group, Cereal Investigations number, and variety.	Yield per acre (bushels).								Date headed.	Date ripe.	To maturity from—		Height.	Weight per bushel.
	1908	1909	1910	1911	1912	1913	1914	Average.			Planting.	Heading.		
											Days	*Days*	*In.*	*Lbs.*
Midseason white:														
731, Abundance	31.3	91.1	12.5	7.7	104.7	93.4	123.9	66.4	July 11	Aug. 4	102	24	36	26.1
738, Lincoln	32.1	96.2	15.6	7.0	101.3	84.5	124.3	65.9	July 10	...do	102	25	36	27.7
741, Siberian	29.0	104.1	10.9	5.1	106.9	79.4	116.4	64.5	July 11	...do	102	24	37	30.7
714, Silvermine	37.4	103.3	14.8	7.3	95.7	67.5	120.7	63.8	July 10	Aug. 3	102	24	35	32.0
739, Myrick	27.3	99.4	8.9	10.0	107.8	82.5	102.3	61.3	July 11	Aug. 5	103	25	35	29.7
134, Swedish Select	28.4	86.0	7.8	9.9	84.4	68.8	97.3	54.7	July 9	Aug. 2	101	24	36	30.7
Midseason yellow:														
495, Probsteier	36.1	95.0	9.4	6.1	101.3	72.0	112.8	61.8	July 11	Aug. 5	102	25	36	31.0
Late white:														
732, White Russian	23.0	70.8	13.0	2.9	120.6	80.3	102.0	58.9	July 15	Aug. 9	107	25	38	30.4
744, White Russian	20.6	79.0	11.0	2.2	103.2	76.3	102.4	56.4	...do	...do	107	25	38	30.9
713, Tartarian	21.4	67.4	11.5	1.3	118.8	83.1	66.8	52.9	...do	Aug. 6	106	22	37	29.3
Early yellow:														
165, Sixty-Day	28.8	76.3	4.2	11.2	50.3	45.0	82.2	42.6	June 29	July 24	89	25	29	30.0

MIDSEASON VARIETIES.

Seven of the eleven varieties under discussion may be classed as medium in maturity. The average date of ripening of these varieties for the seven years ranges from August 2 to 5, 101 to 103 days being required from seeding to maturity. Six of these varieties have yielded more than any of the early or late oats, while the seventh, Swedish Select, has yielded less than the two stocks of White Russian. All are open-panicled varieties and all have white hulls except Probsteier, which is yellowish white.

The farmer in the locality of Williston who grows any of these varieties, with the possible exception of Swedish Select, will make no mistake. The average yields here reported show that there is little choice between them, though Abundance, Lincoln, Siberian, and Silvermine have slightly exceeded the others in average yield, due in part to their extremely high yields in 1914. The weight per bushel of the Silvermine is higher than that of any of the other varieties in the test.

LATE VARIETIES.

The White Russian and Tartarian are very similar, if not identical, varieties of late oats. They mature about August 6 to 9 at Williston, requiring from four to six days more from seeding to maturity than the midseason varieties just discussed. The heads are long, compact, and turned to one side (side, or horse-mane, oats). The kernels are white, long, and slender. In favorable seasons they usually yield well, but in ordinary or particularly unfavorable years they usually fall far below the earlier varieties.

The 7-year average yield of the best White Russian (C. I. No. 732) is 7½ bushels lower than that of Abundance, the best open-panicled variety. Both stocks of White Russian have yielded more than the Tartarian, though the difference is largely due to the low yield of the latter in 1914. The yield of the Tartarian was low in 1914 because of poor germination and the poor stand which resulted.

Except where large acreages of oats are grown, so that it is desirable to have the maturity of the crop extend over a considerable period to prevent losses in harvesting, the growing of side oats in this district is not recommended.

RATE-OF-SEEDING TEST WITH OATS.

A rate-of-seeding test with oats has been conducted for four years (1911 to 1914) at Williston. The Swedish Select variety has been used in this test, in which the rates of seeding were 2, 4, 6, 8, and 10 pecks. The 10-peck rate of seeding was discontinued in 1914. The results of this experiment are shown in Table XIV.

TABLE XIV.—*Annual and average yields in a rate-of-seeding test of Swedish Select oats at the Williston substation, 1911 to 1914, inclusive.*

Rate of seeding.	Yield per acre (bushels).				
	1911	1912	1913	1914	Average.
2 pecks	3.5	76.9	38.8	82.2	50.4
4 pecks	6.0	70.0	73.8	97.3	61.8
6 pecks	6.4	53.7	78.1	108.2	61.6
8 pecks	7.3	60.0	75.6	111.4	63.6
10 pecks	10.8	64.4	73.0	.....	.....

The highest average yield, 63.6 bushels, as shown in Table XIV, has been obtained from the 8-peck rate. This yield, however, is only slightly higher than was obtained from the 4-peck and 6-peck rates, and when the extra bushel of seed required is taken into account it exceeds the 4-peck rate by only 0.8 bushel.

Attention is called to the fact that three of the four years during which the test has been conducted have been favorable ones for crop production and that one of them (1914) was particularly favorable for oats. Experiments elsewhere in the Great Plains have shown that the higher rates of seeding for the various cereals usually give best returns in favorable years, but that in ordinary or unfavorable years the lower rates are better. If the particularly favorable year (1914) is disregarded, the average yield from the 4-peck rate at Williston for the preceding three years is about 3 bushels higher than from either of the higher rates. At present, therefore, it appears to be advisable to recommend sowing from 4 to 6 pecks of oats to the acre in the Williston district. This test will be continued and the results reported at a later date.

EXPERIMENTS WITH BARLEY.

Practically all the varieties of barley which have been grown at Williston have been of the ordinary hulled (common) class, though two naked (hull-less) varieties have been included in the tests. All the varieties, with the exception of Nepal, are bearded. About two-thirds of the hulled varieties are 6-rowed and one-third 2-rowed. The annual and average yields of the 26 varieties and races of barley which have been grown at Williston for the seven years from 1908 to 1914 are given in Table XV. Of these 26 varieties only 14 were tested in 1914, the others having been discarded previously.

LEADING VARIETIES.

As shown in Table XV, the yields of only six varieties of barley are available for the full period of seven years. Of these, four are 6-rowed and two are 2-rowed barleys. All are bearded and all are hulled (common) varieties. The few naked and hooded varieties which have been grown at Williston have produced very low yields.

TABLE XV.—*Annual and average yields of 26 varieties of barley grown at the Williston substation, 1908 to 1914, inclusive.*

Group, Cereal Investigations number, and variety.	Yield per acre (bushels).							
	1908	1909	1910	1911	1912	1913	1914	Average.
Six-rowed hulled group:								
881, Bernard (N. Dak. No. 789)	17.1	52.1	5.7	9.8	62.9	40.0	53.9	34.5
575, Gatami	.....	.....	7.3	19.5	59.2	(1)	53.2	34.8
638, Manchuria (Minn. No. 6)	15.7	57.0	8.1	6.6	74.0	44.8	53.2	37.1
643, Manchuria (Minn. No. 105)	14.2	49.4	6.7	11.0	71.5	37.1	65.1	36.4
739, Manchuria	.....	.....	.....	.....	58.3	46.3	76.6	60.4
879, Manchuria (Minn. No. 32)	13.7	50.3	3.8	5.7	59.8	.....	.....	26.7
880, Manchuria (Minn. No. 87)	9.8	51.3	2.6	8.5	56.9	.....	.....	25.8
885, Manchuria (N. Dak. No. 172)	6.4	56.0	2.0	8.1	51.2	.....	.....	24.7
886, Manchuria (N. Dak. No. 252)	9.5	51.9	5.1	9.8	63.1	.....	.....	27.9
887, Manchuria (N. Dak. No. 871)	13.3	53.5	4.5	10.2	60.8	(1)	52.4	32.5
888, Oderbrucker	.....	55.6	3.7	7.7	61.3	49.8	52.9	38.5
889, Read Triumph	.....	46.8	2.2	5.1	61.5	51.8	.....	33.5
..., Russian (N. Dak. No. 107)	11.3	57.8	3.9	4.3	60.6	.....	.....	27.6
890, Silver King (N. Dak. No. 719)	12.0	57.2	4.7	7.7	63.1	35.4	.....	30.0
882, Williston No. 170 (N. Dak. No. 966)	18.2	53.7	6.7	12.3	65.5	51.3	71.3	39.9
Average of 6-rowed hulled	12.8	53.3	4.1	9.0	62.0	44.6	59.8	.....
Two-rowed hulled group:								
740, Canadian Thorpe	.....	.....	.....	.....	50.0	.....	.....	.....
203, Hanna (N. Dak. No. 649)	10.0	56.0	3.9	10.6	65.8	19.6	66.7	33.2
531, Hannchen	.....	.....	.....	.....	.....	26.2	72.9	49.6
883, Highland Chief (N. Dak. No. 847)	10.6	47.8	2.4	5.5	66.6	24.0	.....	26.1
532, Primus	.....	.....	.....	.....	.....	.....	63.6	.....
893, Proskowetz	.....	.....	.....	.....	.....	25.8	54.7	40.3
891, Success (N. Dak. No. 171)[2]	11.3	46.0	1.2	8.5	68.3	26.9	48.5	30.1
187, Svanhals	.....	.....	.....	.....	.....	.....	53.7	.....
Average of 2-rowed hulled	10.6	49.9	2.5	8.2	62.7	24.7	60.2	.....
Six-rowed naked group:								
884, Nepal[3]	.....	33.3	1.4	6.5	41.7	.....	.....	20.7
Two-rowed naked group:								
892, McEwan (N. Dak. No. 149)[3]	.....	.....	3.6	5.8	36.0	.....	.....	15.1
Summary of averages:								
Six-rowed hulled	12.8	53.3	4.1	9.0	62.0	44.6	59.8	.....
Two-rowed hulled	10.6	49.9	2.5	8.2	62.7	24.7	60.2	.....
Six-rowed naked	.....	33.3	1.4	6.5	41.7	.....	.....	.....
Two-rowed naked	.....	.....	3.6	5.8	36.0	.....	.....	.....

[1] Record lost.
[2] This variety is distinct from the 6-rowed hooded hulled variety commonly known as Success, for which the name Horsford is preferable.
[3] Yields in bushels of 60 pounds; yields of other varieties in bushels of 48 pounds.

The annual and average yields, the average dates of heading and ripening, height, yield per acre, and weight per bushel of these six varieties are shown in Table XVI. In this table the varieties are arranged according to their average yields for the 7-year period. These yields are shown graphically in figure 10. Figure 11 shows heads of representative varieties of three different groups of barley grown at Williston.

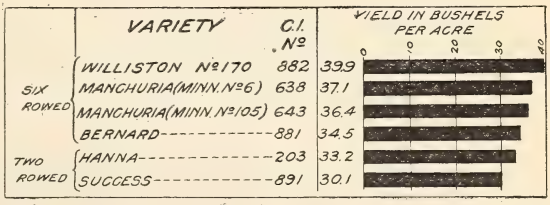

FIG. 10.—Diagram showing the average yields of six varieties of barley at the Williston substation, 1908 to 1914, inclusive.

The average annual yield of the four 6-rowed barleys has been greater in each of the seven years than the average annual yield of the two 2-rowed varieties (Table XVI). The average yield for the entire period is 37 and 31.6 bushels, respectively. Quite different results

FIG. 11.—Heads of three varieties of barley grown at the Williston substation: 1, Manchuria; 2, Svanhals; 3, Hannchen.

were obtained at the Dickinson substation, where the 2-rowed varieties considerably exceeded the 6-rowed in yield.[1]

SIX-ROWED VARIETIES.

All the 6-rowed varieties listed in Table XVI are very similar in appearance. They all belong to the Manchuria group, which is the barley commonly grown in Wisconsin and Minnesota.

The highest average yield for the 7-year period (1908 to 1914), 39.9 bushels, has been produced by the Williston No. 170 (C. I. No. 882),

[1] Clark, J. A. Cereal Experiments at Dickinson, N. Dak. U. S. Dept. Agr. Bul. No. 33, 1914, p. 31–36.

an unnamed variety of the Manchuria group grown locally near Williston. Since 1910, as noted in Table XVI, the yields reported are for a pure-line selection from the original stock of Williston No. 170. The average yields of two lots of Manchuria (Minn. No. 6, C. I. No. 638, and Minn. No. 105, C. I. No. 643) for the seven years are 37.1 and 36.4 bushels, respectively.

The Bernard (C. I. No. 881) is another local variety similar to Manchuria. The average yield of this variety for the seven years is considerably lower than that of the others here reported.

TABLE XVI.—*Annual and average yields, growth data, and weight per bushel of six standard varieties of barley grown at the Williston substation, 1908 to 1914, inclusive.*

Group, Cereal Investigations number, and variety.	Yield per acre (bushels).								Date headed.	Date ripe.	To maturity from —		Height.	Weight per bushel.
	1908	1909	1910	1911	1912	1913	1914	Average.			Planting.	Heading.		
Six-rowed:											*Days.*	*Days.*	*In.*	*Lbs.*
882, Williston No. 170[1]	18.2	53.7	6.7	12.3	65.5	51.3	71.3	39.9	July 5	July 26	88	21	34	45.4
638, Manchuria (Minn. No. 6)	15.7	57.0	8.1	6.6	74.0	44.8	53.2	37.1	July 6	...do....	88	20	32	44.9
643, Manchuria (Minn. No. 105)	14.2	49.4	6.7	11.0	71.5	37.1	65.1	36.4	...do....	...do....	88	20	32	46.6
881, Bernard	17.1	52.1	5.7	9.8	62.9	40.0	53.9	34.5	...do....	July 25	87	19	33	46.6
Average	16.3	53.1	6.8	9.9	68.5	43.3	60.8	37.0						
Two-rowed:														
203, Hanna	10.0	56.0	3.9	10.6	65.8	19.6	66.7	33.2	July 10	July 27	90	17	27	47.7
891, Success	11.3	46.0	1.2	8.5	68.3	26.9	48.5	30.1	July 15	Aug. 2	96	18	26	47.2
Average	10.7	51.0	2.6	9.6	67.1	23.3	57.6	31.6						

[1] In 1910 and succeeding years the yields reported are those obtained from a pure-line selection from the original Williston No. 170, a variety of the Manchuria group.

The average date of maturity of the 6-rowed varieties, as shown in Table XVI, is July 26, which is one day earlier than that of Hanna and seven days earlier than that of Success, the two 2-rowed varieties. The average height of the 6-rowed varieties, 32 to 34 inches, is several inches more than that of the 2-rowed varieties, an important matter in dry-land farming, where barley and other grain is sometimes too short to harvest with the binder. In weight per bushel the 2-rowed varieties have exceeded the 6-rowed, the average weight of the former being 47.2 to 47.7 pounds, while the four 6-rowed varieties vary from 44.9 to 46.6 pounds.

TWO-ROWED VARIETIES.

The two 2-rowed varieties, Hanna (C. I. No. 203) and Success (C. I. No. 891), as already stated, show a lower average yield for the seven years than any of the four 6-rowed varieties included in Table XVI. The average yield for Hanna is 33.2 bushels and for Success 30.1 bushels. The Hanna has yielded more than the Williston No. 170 in

only two of the seven years, and in these two years the differences were very slight. It has also yielded more than the Manchuria (C. I. No. 638) in only two years, 1910 and 1914, but in both cases the difference has been considerable. The Success has yielded more than Williston No. 170 and Manchuria (C. I. No. 638) in only one of the seven years.

The unsatisfactory yields of the 2-rowed varieties may be due in part to an unfortunate choice of varieties. However, their performance thus far does not warrant recommending them for this section or describing them in detail in this bulletin.

NURSERY TESTS OF BARLEY.

A considerable number of varieties and stocks of barley have been grown in the nursery at Williston. All the varieties grown in the field plats, as well as a number of others, were grown in the nursery. The greater part of these varieties, as in the field tests, were 6-rowed and 2-rowed bearded hulled barleys, but 2-rowed and 6-rowed bearded naked and 6-rowed hooded naked varieties were also included.

The number of varieties in each class, with the average number of days from seeding to maturity, height, length of head, number of stools and of heads per plant, weight of 1,000 kernels, and weight of straw and of grain from a rod row for each class in 1912 and 1913 are shown in Table XVII.

TABLE XVII.—*Average miscellaneous data for the various classes of barley grown in the nursery at the Williston substation in 1912 and 1913.*

Class.	Number of races.	Days to maturity.	Height.	Length of head.	Stools per plant.	Heads per plant.	Weight of 1,000 kernels.	Yield from rod row.	
								Straw.	Grain.
			Inches.	*Inches.*			*Grams.*	*Grams.*	*Grams.*
Bearded hulled:									
Six-rowed	30	91	29.5	2.50	7.59	5.90	40.5	521	459.5
Two-rowed	27	92	29.0	3.15	9.50	7.46	45.1	589	430.9
Bearded naked:									
Six-rowed	9	86	25.3	2.35	7.39	5.30	37.7	514	362.1
Two-rowed	5	85	24.1	2.41	7.32	5.44	49.8	513	372.1
Hooded naked:									
Six-rowed	3	87	30.0	2.59	6.77	4.40	45.1	522	348.2

The naked varieties, as shown in Table XVII, mature somewhat more quickly and, with the exception of the hooded forms, have shorter straw than the hulled varieties. The 2-rowed hulled varieties stool more freely and produce more and longer heads than those of any of the other classes. The weight of 1,000 kernels is greatest for the 2-rowed naked varieties, exceeding that of the 2-rowed hulled by 4.7 grams. The yield of straw per row was greatest from the 2-rowed hulled class, while the yield of grain was largest from the 6-rowed hulled varieties.

EXPERIMENTS WITH FLAX.

The yields obtained from the varieties of flax that have been tested at Williston are shown in Table XVIII. In 1908 the flax was sown on ground that produced oats the previous year. In 1909, 1910, and 1912 the flax varieties were tested on breaking. In 1911 they were on ground that was planted to corn the previous year, but that crop was destroyed by hail in August. In 1913 and 1914 the varieties were sown on fallow ground. In both these years the plats were so overgrown with Russian thistles that the yields were not considered comparable and hence are not reported.

TABLE XVIII.—*Annual and average yields of six varieties of flax grown at the Williston substation, 1908 to 1912, inclusive.*[1]

C. I. No.	Variety.	Yield per acre (bushels).				
		1908	1909	1910	1912	Average.
16	North Dakota No. 1221	8.5	23.5	5.4	27.5	16.2
17	North Dakota No. 155	7.4	22.4	6.5	26.8	15.8
18	North Dakota No. 1133	7.8	21.7	5.2	27.2	15.5
10	Primost	.....	14.2	3.6	23.9	.....
8	North Dakota Resistant No. 52	.....	.....	.....	30.0	.....
12	Primost	.....	.....	.....	19.7	.....

[1] These varieties were grown in 1913 and 1914, but the plats were so overgrown with Russian thistles that comparable yields could not be obtained.

The average yields of the three lots of flax that have been grown for the four years (1909 to 1912) are practically the same, ranging from 15.5 to 16.2 bushels. In 1912 the race known as North Dakota Resistant No. 52, which was included in the tests for the first time that year, produced the highest yield.

EXPERIMENTS WITH MINOR CEREALS.

Experiments with the minor spring cereals at Williston have included three varieties of emmer, one of rye, one of spelt, one of proso, and one of millet. While emmer has given good yields for most of the six years tested, it has not proved to be a better crop than barley. Table XIX presents the annual and average yields for six years (1909 to 1914) of one variety of emmer and one of rye with those of standard varieties of durum and common wheat and of oats and barley for comparison. The average yields per acre are given in pounds as well as bushels, so that the comparison can be made more readily.

Table XIX shows that oats produced more pounds of grain per acre than the best varieties of wheat, barley, emmer, and rye. The average yield of Siberian oats for the six years was 2,256 pounds to the acre; of Kubanka durum and Power fife wheat, 1,968 and 1,872 pounds, respectively; of Manchuria barley (Williston No. 170), 2,088 pounds; of emmer, 1,580 pounds; and of rye, 1,377 pounds.

TABLE XIX.—*Annual and average yields of six varieties of cereals grown at the Williston substation, 1909 to 1914, inclusive.*

C. I. No.	Variety and cereal.	Yield per acre.							
		1909	1910	1911	1912	1913	1914	Average.	
		Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Lbs.*
1440	Kubanka durum wheat	31.9	11.0	8.9	51.0	33.0	53.8	32.8	1,968
3697	Power fife wheat	34.0	17.1	11.1	44.7	28.7	51.3	31.2	1,872
741	Siberian oats	104.1	10.9	5.1	106.9	79.4	116.4	70.5	2,256
882	Williston No. 170 barley	53.7	6.7	12.3	65.5	51.3	71.3	43.5	2,088
	North Dakota No. 305 emmer	54.4	11.3	3.8	79.5	43.0	44.9	39.5	1,580
169	Spring rye	40.0	6.1	9.1	43.6	16.3	32.3	24.6	1,377

The stand of the North Dakota No. 305 emmer in 1914 was very thin; hence, the yield was abnormally low. For this reason the comparison of average yields for the six years shown in Table XIX is somewhat unfair to the emmer. White spring emmer grown on an adjoining plat yielded 85 bushels to the acre. If this yield is substituted for that of the North Dakota No. 305 in the table, the average yield is increased to 1,847 pounds. White spring spelt (C. I. No. 2968) was grown only in 1914, when it yielded 70.6 bushels to the acre. Since the grains of emmer and spelt remain in the glumes after thrashing, they are more comparable to oats and barley than to wheat and rye. The yields here reported indicate that it is not advisable to substitute spring emmer or spelt for oats or barley as a feed grain in the Williston district.

In 1912, 1913, and 1914 Black Voronezh proso (C. I. No. 16) was grown in field plats. The yields of grain for the three years were 24, 22.1, and 29 bushels per acre, respectively.

In 1914 Kursk millet was also tested in a field plat, producing a yield of 38 bushels of seed per acre, 9 bushels more than the Black Voronezh proso for the same year.

In prosos the seeds ripen first at the tips of the heads. The crop may be cut when most of the head is ripe and the tip begins to shatter. The straw and leaves are still green at this stage, but the shocking may be done so as to permit perfect curing without molding. A fair quality of hay remains after the seed is thrashed out.

Grain sorghums, especially early kaoliangs, have been tried at Williston, but thus far have matured little grain. The grain sorghums do not compare favorably in this district with the best varieties of corn.

SUMMARY.

Cooperative experiments with cereals at the Williston substation have been conducted for the seven years from 1908 to 1914, inclusive.

The Williston substation is located in the extreme southern part of Williams County, in northwestern North Dakota, at an altitude of approximately 1,900 feet.

The average annual precipitation at Williston for the 36 years from 1879 to 1914, inclusive, was 14.9 inches. The average seasonal rainfall (April to July, inclusive) for these years was 8.86 inches. The heaviest rainfall at Williston occurs during the growing season.

The average evaporation from a free water surface at the Williston substation during the growing season for the years 1909 to 1914, inclusive, was 24.03 inches. The average precipitation for the same period was 8.43 inches.

The average wind velocity per hour during the months from April to July, inclusive, for the years 1909 to 1914, inclusive, was 6.6 miles.

The average length of the frost-free period for the 33 years has been 119 days. The average date of the last killing frost in the spring has been May 18 and of the first killing frost in the fall, September 14.

The soil at the Williston substation on which the cereal varieties have been tested consists of a fine sandy loam.

The varietal tests on plats have included 36 varieties and strains of spring wheat, 40 of oats, 27 of barley, and a few each of flax, emmer, spelt, rye, proso, and winter wheat.

Spring wheats have given better results than winter wheats.

Except in the dry years, 1910 and 1911, the durum wheats have produced higher yields than the common spring wheats.

Kubanka durum wheat (C. I. No. 1440) gave the highest average yield of all of the spring wheats tested from 1908 to 1914, inclusive, 29.9 bushels per acre. Power fife wheat (C. I. No. 3697) stood second for the same period, producing 28.6 bushels per acre.

The bluestem group has not yielded as well as the durums and fifes, and the average weight per bushel has also been lower.

Rate-of-seeding tests with bluestem spring wheat have indicated that the highest yields are obtained from sowing 4 pecks to the acre.

The average yields from winter wheat are lower than those from the spring wheats, for winter wheat frequently winterkills. Sowing winter wheat in grain stubble or standing corn gives protection to the plants and reduces the loss from winterkilling.

The best three varieties of oats for the seven years, 1908 to 1914, are Abundance, with an average yield of 66.4 bushels per acre; Lincoln, 65.9 bushels; and Siberian, 64.5 bushels. These are all midseason varieties. The late-maturing varieties, such as White Russian, and the very early varieties, Sixty-Day and Kherson, have yielded much less than the midseason varieties.

Rate-of-seeding tests with Swedish Select oats indicate that the best yields are obtained by sowing from 4 to 6 pecks per acre.

The 6-rowed group of barley has yielded better than the 2-rowed group. The highest average yield for the seven years (1908 to 1914),

39.9 bushels, has been produced by the Williston No. 170 (C. I. No. 882), a strain of Manchuria barley.

Flax is grown with some difficulty on ground that is infested with weeds. In the seven years that tests were made, only four crops were harvested. The average yield of the highest producing variety for these four years was 16.2 bushels per acre from the North Dakota No. 1221 (C. I. No. 16).

Emmer and spring rye have not given as high average yields as oats, barley, or wheat.

Proso, grown in field plats from 1912 to 1914, inclusive, gave an average yield of seed per acre of 25 bushels. Kursk millet, grown in a plat test in 1914, yielded 38 bushels of seed per acre.

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